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ABSTRACT

Depending on their programming knowledge, students can become involved with the use of the computer in the construction and analysis of mathematical models, either through observing and/or interacting with a model developed by a programmer, or by becoming involved in the process of constructions and testing of models. The Bush-Mosteller Simple Learning Model is used to illustrate the use of a computer simulation in instruction. (STS)

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THE USE OF COMPUTERS IN SIMULATIONS

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THE USE OF COMPUTERS IN SIMULATIONS

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The use of computing in the construction and analysis of mathematical models is not a new phenomenon. It was originally used by physical scientists to simulate random processes. As computer software became more sophisticated, the technical difficulties of programming were drastically reduced and social scientists were able to use computer simulation methods without having to invest extraordinary effort to overcome programming difficulties.

More recently, the development of easy-to-use languages such as BASIC (particularly in timesharing environments) has made it possible for undergraduates, even from non-scientific disciplines, to use computing as a more meaningful part of their learning experience.

One common way of using computer simulations in teaching is to prepare or have a programmer prepare a program or a package (a collection of programs) for the teaching of specific principles. Students then use the programs to observe the behavior of the programmed model. Although this approach clearly has considerable merit, it leaves the student out of the most crucial and instructive phase of learning - that of model design. In this approach the model is designed by the instructor or programmer and the students observes and interacts with the model. Students

have to learn some programming to actually be involved in the process of the construction and testing of models. Yet, in most instances a great deal of instruction on programming diverts the student's attention from the actual problem at hand. It is difficult to decide the extent of programming ability (as minimal as that may be) that students should have as preparation for courses which involve modeling; but some programming knowledge is, I think, essential. An ideal solution, of course, would be to introduce students to computing concepts as part of their general education experience. As Denison University approximately 60% of the students choose to take at least one course which exposes them to computing and programming concepts.

The most difficult aspect of modeling is the determination of those assumptions (axioms) which will yield a model that describes the real-world problem. In practice this process can be extremely cumbersome since it is likely to involve many false-starts or modifications of the original assumptions. As computers (hence computer time) have become less expensive, it has become feasible to use computing for the purpose of gaining insight into the complexities of a problem before a precise mathematical formulation is developed. Hopefully this preceedure will eliminate unproductive approaches with minimal effort.

To illustrate the use of computer simulations, I have chosen a simple learning model which does not need a great deal of analysis. It was originally proposed by R. Bush and F. Mosteller in 1951. Since then a number of modifications have been made to the initial model.

THE MODEL

Let P(N) be the probability of a certain response in the N-th repetition of a stimulus-response experiment. The learning model (Gain-Loss Model) proposed by Bush and Mosteller can be expressed by the following relation:

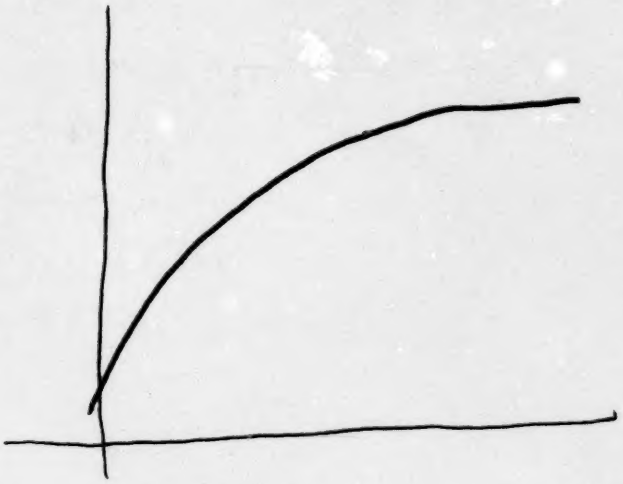
$$P(N=1) = A(1 - P(N)) - BP(N) = P(N)$$

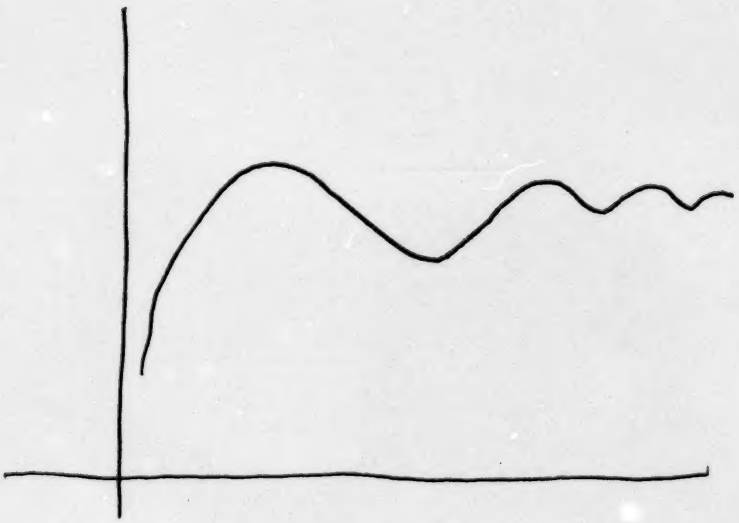
P(N), the probability of the desired response, is used as an indicator of the 'amount learned' by the subject. A can be though of as the gain factor because P(N) is incremented by A(1-P(N)) where 1-P(N) is the maximum that can be gained. B on the other hand, is the loss factor and multiplies P(N), the probability which can be lost.

One of the simplest ways of determining the feasibility of this model would be to determine the patterns of learning and other implication of the model by selecting

various values of A, B, and P(0), Once this is done we can then decide if our observations are in conflict with actual experimental data. A simple program (1Ø lines) with input parameters A, B, and P(0) can develop our intuition and expose some of the consequences of the model. A BASIC+ program and some graphic output illustrating some of the consequences of the model are given below:

```
1Ø  !  THE BUSH-MOSTELLER SIMPLE LEARNING MODEL
2Ø       OPEN "LEARN" FOR OUTPUT AS FILE 1
3Ø  DIM  1, x(1ØØ,7)  :  x(Ø.Ø)=8  ;  x(Ø,1)=5
4Ø  N=8
5Ø  INPUT "ENTER A AND B"; A,B
6Ø  FOR J=1 TO 4
7Ø      P=J*Ø.2
8Ø      X(1,J=1)=(1-A-B)*P=A FOR I=1 TO N
9Ø  NEXT J
1ØØ CLOSE 1 : CHAIN "(3,5)GRAPH2" : END
```





A study of the putpet, leads to the following observations.

1. The long-term learning outcome, that is the value of P(N) for large N, is independent of P(0), the original state. This can be seen in Fig. 1.
2. Under certain assumptions, learning increases monotonically with the number of repetitions of the experiment as shown in Fig. 2.
3. For different choices of A and B, the learning process may consist of a sequence of gains (learning) and losses (forgetting) which in the long-run balance at some level. This is shown in Fib. 3.

There are also other possibilities which students can discover by trying other values of A and B. If these observations are contrary to the experimental data, the proposed model will have to be modified (or in the extreme case abandoned). If, on the other hand, the observations support experimental results, then a more precise methematical formulation is not possible, the general computational investigation of the problem is even more important.

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